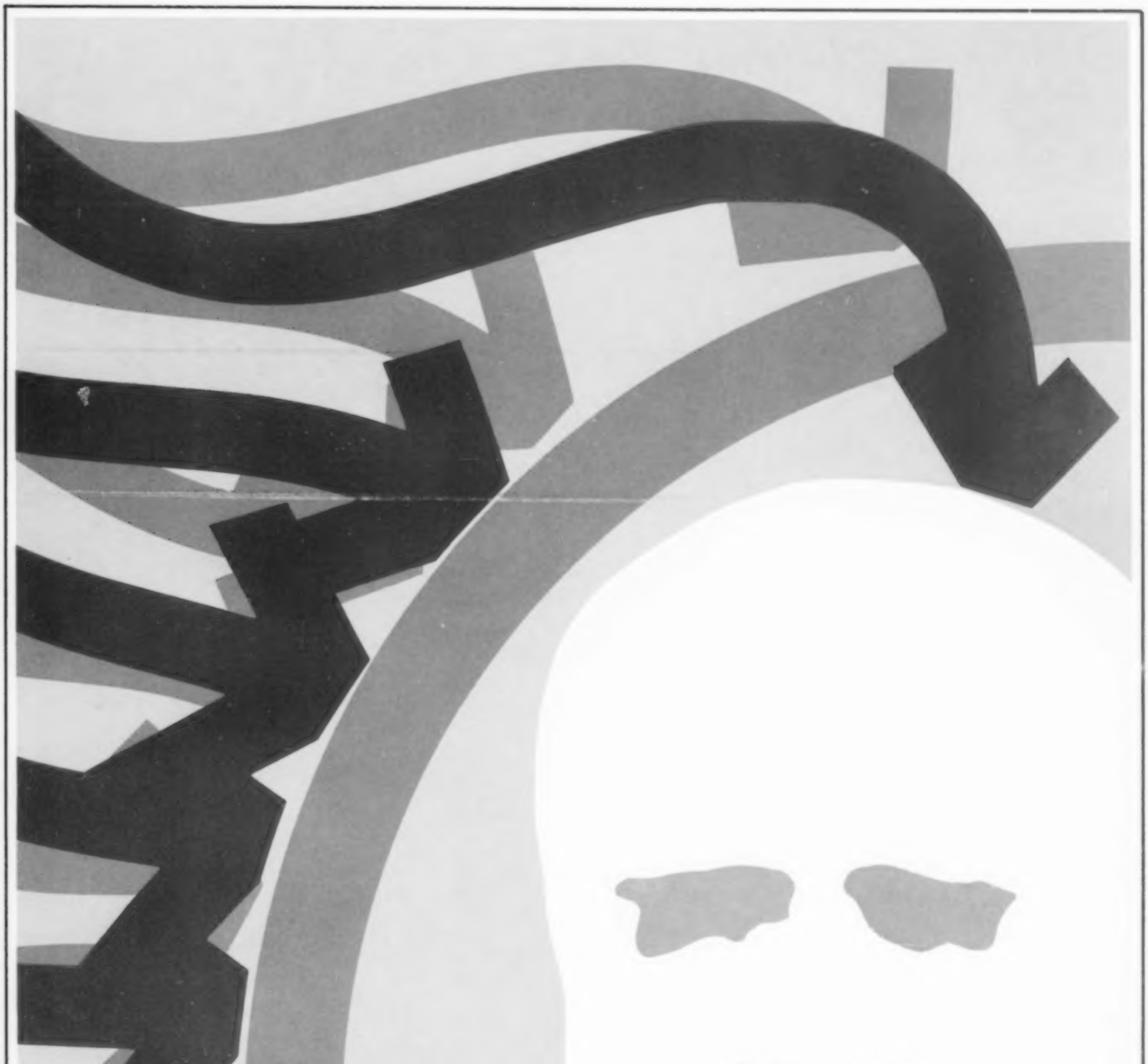
DIMENSIONS NBS

The magazine of the
National Bureau
of Standards
U.S. Department
of Commerce

February 1978



INFORMATION SYSTEMS. See page 10.

COMMENT

IN MEMORIAM

It was with the deepest regret that I learned of the death of Dr. Richard W. Roberts on Tuesday, January 17, 1978. During most of his tenure as director of the National Bureau of Standards, I served as deputy director. We worked closely, and I believe successfully, together. His enthusiasm and energy were tremendous. Nothing was done in a half-hearted way.

Dick Roberts took an interest in everyone and everything at NBS. As a manager, he worked tirelessly to pull together the varied programs of the Bureau and to get people to perform up to their maximum capabilities. He always gave unstintingly of himself. He taught us a great deal about how to present our work to the outside world and to each other. He stands out in my mind as a man of many qualities, but he was particularly inspiring as a motivator and a communicator. This, in my opinion, was his personal legacy to NBS.

All of us will miss him greatly.

Ernest Ambler

Ernest Ambler
Director
National Bureau of Standards

RICHARD W. ROBERTS,
director of NBS from February 1973 to June 1975, died suddenly at his home in Wilton, Connecticut, on January 17. Roberts was 43 on January 12. He had recently joined the General Electric Company after having served as Assistant Administrator for Nuclear Energy in the Energy Research and Development Administration.

Roberts was the seventh director of NBS and the first chemist to head the Bureau. He came to NBS from GE's Corporate Research and Development Center in Schenectady, New York, where he directed the materials science and engineering laboratories.

As head of NBS, Roberts distinguished himself in the areas of leadership and effective administration. During the energy crisis and oil embargo of 1973, the Bureau, under Roberts' direction, took actions that resulted in a 20 percent savings on site—making NBS a model of what could be accomplished by control and wise energy management. He also achieved outstanding improvements in Bureau management policies. For these accomplishments, Roberts won the Arthur S. Flemming Award in 1975. This award is presented annually to outstanding young employees of the federal government.

A native of Buffalo, N.Y., Roberts received his B.S. degree in chemistry from the University of Rochester in 1956 and his Ph.D. in physical chemistry from Brown University in 1959. Also in 1959, Roberts served as a National Academy of Sciences Postdoctoral Fellow, working at NBS on surface chemistry. He joined GE in 1960, where he became internationally known for his studies of ultrahigh vacuum technology, the physical and chemical properties of atomically clean metal and semiconductor surfaces, chemical kinetics, and the lubrication of space age metals.

At the time of his death, Roberts was Staff Executive on GE's Corporate Technology Staff. Dr. Charles Reed, GE senior vice president-Corporate Technology Staff, described Roberts as "a brilliant and dedicated individual who leaves behind a truly memorable record as a scientist, as well as innumerable close friends and associates."

Roberts is survived by his wife, Carol, and two children, Beth Carol, 15, and William Charles 12; his parents Mr. and Mrs. William Roberts; and his sister Mrs. C. L. Armstrong. The Roberts made their home at 92 Drum Hill Road, Wilton, Connecticut. A memorial fund is being established in his name at the University of Rochester. Contributions should be payable to the University of Rochester, with a note on the check specifying "RWR Memorial Fund." They may be mailed to the Gift Office, University of Rochester, Rochester, N.Y. 14627.

DIMENSIONS NBS

The magazine of the
National Bureau of Standards
U.S. Department of Commerce
Volume 62/Number 2

February 1978

Contents

Piezoelectricity

Working Under Pressure: The Varied World of the Piezoelectric Polymer

by Madeleine Jacobs

IT'S been a long hard day at the office and you're tired. You arrive at home, kick off your shoes, settle down in your favorite easy chair, and turn on the stereo. Suddenly, it's as if you're sitting in a concert hall, listening to Berlioz' Symphonie Fantastique. The music can only be described as exquisite.

The realism of the sound is due to a specially processed polymer material in the stereo speakers that makes it possible to transform electrical energy into acoustical energy with nearly complete accuracy. The unique substance is an example of a class of materials known as piezoelectric (often pronounced pē - ā´- zo - electric) polymers. Their use is so new that the *Encyclopedia Britannica* fails to mention them in its section on "Piezoelectric Devices." And yet, as a class, piezoelectric polymers are being used increasingly, not only in some stereo components but also in applications involving health, safety, national security, nondestructive evaluation, and even printing of our currency.

"The most surprising thing about piezoelectric polymers is that they exist," declares Seymour Edelman, a physicist at the National Bureau of Standards and a leading pioneer in the field of piezoelectric polymer applications. "Polymers differ from conventional piezoelectric materials in so many of their properties that it seems strange that they should be comparable in their piezoelectric response.

"For example, conventional piezoelectric materials are typically crystalline or polycrystalline, hard, stiff, brittle, and dense," he continues. "They're difficult to machine into thin layers, they are not readily available in sheets of large area, and they are expensive. On the other hand, polymers are pliant, flexible, tough, and light. They are available commercially in layers as thin as 6 micrometers in 1000 meter rolls over 1 meter wide. And they are relatively inexpensive."

These properties make polymers uniquely suited for a variety of piezoelectric devices. While the Japanese have been studying the phenomenon in polymers longer than anyone else, NBS* is at the vanguard of a handful of laboratories in the United States studying the theory, materials properties, and applications of this strange class of polymers.

Piezoelectricity—Electricity induced by applying pressure to certain materials, particularly crystals.

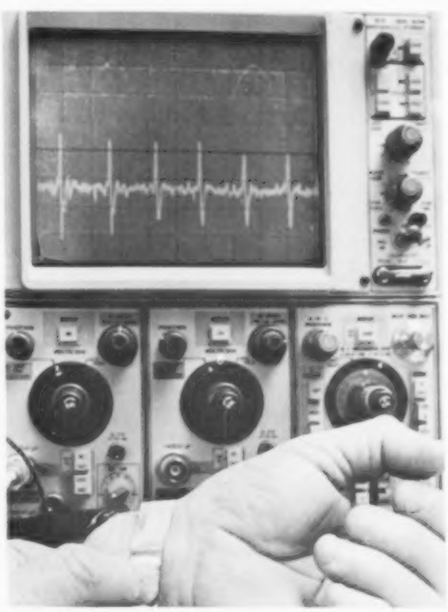
Scientific Curiosity

Most piezoelectric devices today are based on certain crystals which, when deformed by pressure, generate an electric charge. The phenomenon is due to the electrically polar nature of the crystals. That is, they contain positively and negatively charged ions which separate when the crystals are subjected to stress.

This effect was discovered experimentally in 1880 by the Curie brothers, Pierre and Paul-Jacques. By

turn page

* Research on piezoelectric polymers at NBS is being carried out primarily in the Bulk Properties Section of the Polymers Division in the Institute for Materials Research. A number of scientists have been and are involved in this research, currently under the direction of Dr. Martin Broadhurst. Other researchers now engaged in the research are (in alphabetical order): G. Thomas Davis, Aime S. DeReggi, Seymour Edelman, James M. Kenney, John E. McKinney, and Steven C. Roth.



Thermal pulse experiments (opposite page) yield information about the phenomenon of piezoelectricity in polymers. A light pipe is shown illuminating a polymer sample.

The similarity of piezoelectric polymers to body tissues means that the devices can be applied easily to skin. Oscilloscope screen (left) shows pulse pattern taken with such a device.

Jacobs is a writer and public information specialist in the NBS Office of Information Activities.

Polymer—Any of a number of chemical compounds made up of the same basic molecular subunits which are joined, usually in a definite order, to make large, complex molecules. Some polymers, including silk, occur naturally, but many—like nylon—are synthetic.

placing a weight on a crystal, they observed a voltage on the surface of the material. The inverse effect was also found—that is, by applying a voltage to the material, a deformation of the crystal could be produced. The two effects go together in piezoelectric materials. (The latter is the basis for the use of piezoelectric devices in stereo components and other acoustically-based instruments).

Eventually, they found the effect in a number of crystals, including quartz, Rochelle salt, and tourmaline. Although Pierre Curie and his wife Marie later used the piezoelectric effect to study radioactivity, piezoelectricity in general remained a scientific curiosity until World War I, when it was used to produce acoustic waves in seawater to detect the presence of submarines.

Applications of the effect involved ceramics and other brittle crystalline materials. The first indication that still other substances might exhibit the effect came in 1892. A British scientist, Oliver Heaviside, postulated that certain waxes would form permanently polarized dielectrics* when allowed to solidify from the molten state in the presence of an electric field. He viewed these as being the electrical analog of magnets. His theory was confirmed in the 1920's, but not much else happened until the early 1940's when researchers in other countries began investigating piezoelectric effects in rubber and other materials.

NBS became involved in the research around 1968, recalls Edelman, who was then chief of the Vibration Section. "One of the major problems we had in calibrating instruments used to measure vibrations was getting rid of low frequency resonances. I had learned that rubber was piezoelectric from Dr. Archibald T. McPherson, then associate director of NBS. It occurred to me that if the surface of the instrument were mounted on such a polymer and if we controlled it electrically, we could get rid of all the resonance frequencies that interfered with our measurements. We then looked at a number of polymers and tested them for piezoelectricity. At that time, there was only a limited amount of research reported in the literature on piezoelectricity in polymers."

Inducing Piezoelectricity

This was the beginning of 10 years of applications research, which has led to the development of many new and innovative devices. At NBS, the development of a device begins with inducing the property of piezoelectricity into a film of poly-(vinylidene fluoride), also known as PVDF. Polymers do not normally exhibit piezoelectric activity to any great extent—it must be induced.

NBS physicist Steve Roth begins with a film of PVDF, which looks much like a roll of ordinary plastic wrap. A layer of aluminum is evaporated on both sides of the film to form metallic electrodes. At this point, the material looks like a thin piece of plastic wrap coated with aluminum foil. Next, Roth places the film in an oven and raises the temperature to about 80 °C. An electric field is concurrently applied, typically on the order of several hundred kilovolts per centimeter of polymer thickness. While the voltage is maintained, the polymer is allowed to return to room temperature. This procedure is referred to as "poling."

The piezoelectric property of the material is stabilized in the polymer as it cools. PVDF as a piezoelectric material has a good response to changes in pressure over a wide range of frequencies, which makes it extremely useful for dynamic measurements. It also has many advantages over conventional ceramic materials.

For example, a variety of transducers* and devices can be made from the finished material in nearly any shape. Transducers using conventional piezoelectric materials usually have metal bases and housings and require threaded holes or specially ground flat surfaces of appreciable area for mounting. Polymer transducers, on the other hand, usually consist only of the active material and a metal lead. The finished film can be attached to the surface to be measured with rubber cement, cyanoacrylate, epoxy, or other cement. The transducer can be attached to curved, twisted, or pliant surfaces.

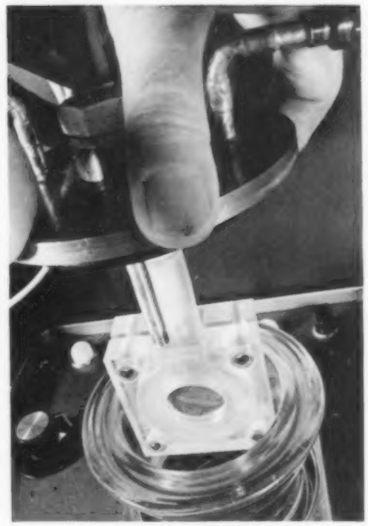
In addition, PVDF is not likely to be harmed by the usual conditions under which sensors are used, such as salt water, soaps, common organic solvents, nearby explosions, or other mechanical shocks.

Conventional transducers also tend to have many large amplitude resonances, both because of their internal spring-mass systems and because of the effect of the mass of the instrument on the mount-

* A dielectric is an electric insulator.

* A transducer is a device that converts power from one form to another. An example is a telephone receiver that is actuated by electric power and supplies acoustic power to the surrounding area.

Seymour Edelman displays variety of piezoelectric polymer transducers. The devices can be made in nearly any desired shape and size.



NBS scientists use a plasma, or ionized gas, to generate poling fields large enough to induce piezoelectricity even at room temperature. Here, a polymer sample is lowered into a glass container where the plasma will be generated.

ing surface. Polymer transducer response is flat with frequency over wide ranges, typically into the megahertz range, their resonances are highly damped, and their mass is so small that they do not perturb the motions of the mounting surface.

Another important property is the piezoelectric modulus, g, which is the electric field per unit mechanical stress. This value governs the usefulness of a material as a detector and is about six times as large for PVDF as for a typical lead zirconate titanate ceramic.

Yet piezoelectric polymer devices are far from perfect for every use. For example, the value of the d modulus (strain per unit electric field), which measures the usefulness of the material as a generator of motion or as a sound source, is 20 times greater for ceramic devices than for polymer devices. (Use of piezoelectric polymers in stereo components is justified on the basis of their other properties and advantages.)

Another problem is temperature. Piezoelectric polymers are also pyroelectric*; that is, they generate an electric charge with a change in temperature as well as with a change in pressure. There is no way to separate the two effects if the temperature and stress are changing together. Fortunately, many measurements are made at constant or slowly changing temperature.

Measurement Problems

Many devices have been developed at NBS which take advantage of the remarkable versatility of piezoelectric polymers. The projects have been supported by other government agencies that have come to NBS for help with a variety of different measurement problems.

For the Frankford Arsenal and the Office of Army Research, for instance, NBS developed piezoelectric polymer devices as detonators for explosives. Edelman and a colleague demonstrated that these devices had sufficient electrical output in response to impact so that they could be used in place of ceramic elements in ordnance fuze systems. This application depends on the fact that in the process of poling, a polymer stores about one and a half times as much energy per unit volume as is stored in ceramic devices under similar conditions. Polymer sheet is also preferable to ceramics for this application because it can be connected to provide a desired electrical output impedance more readily

turn page

* Research on the pyroelectric properties of polymers has also been carried out by two teams of NBS scientists in the Institute for Basic Standards in Boulder, Colorado, and Gaithersburg, Maryland.

and can be used to line a shell to provide detonation on any angle of incidence. For this research, the NBS scientists received an Army Commendation Award.

The thinness and flexibility of polymer gages make them feel and act mechanically very much like skin. These properties were valuable when NBS was asked by the National Highway Traffic Safety Administration of the Department of Transportation to develop polymer stress gages for automobile crash studies. Two types of polymer gages were developed. One was used for pressure changes during the impact of a collision between an anthropomorphic dummy and the instrument panel of a motor vehicle during a simulated crash. The other was used for measuring pressure changes in the brains of animal subjects during tests of controlled impact to the head.

The value of polymer devices in these two applications is obvious, Edelman explains. "Since the gages behave very much like skin, they do not disturb the anthropomorphic behavior of the dummy. Because they are flexible, they are not likely to be damaged in the crash or to damage parts of the vehicle on impact. The polymer gage has a density close to that of brain matter, which makes it useful in the second application. If a conventional ceramic gage were used, inertial effects would produce more signal than the pressure change."

The similarity to body tissues means that polymer gages can be applied easily to the skin like an adhesive bandage to monitor heart sounds and pulse rates of patients during exercise. "Conventional instruments can be used for these applications, but their size and mass make the patient conscious of their presence and his behavior is not entirely normal," Edelman notes. "He is much more likely to forget polymer gages."

Piezoelectric polymers can also be used as strain gages, Edelman says. "In this application, they have nearly the same sensitivity as semiconductor gages but they can be used without the need for bias voltage or bridge balancing. They can be used where mechanical shock occurs and on curved surfaces."

One potentially important use of polymer strain

1

2

gages is to detect and measure strains accompanying stress waves in the soil. These gages might be used to detect and follow tunneling operations, to detect vehicle movements, to calculate the effect of explosions on buried structures, or to detect disturbed ground and buried mines.

Similar gages supplemented by acoustic emission (sound) sensors attached to bedrock can be used to detect and locate mining operations, progress of a tunnel, sudden movements in earth dams, and incipient avalanches in snow fields, Edelman points out. NBS is currently working on developing gages for mining applications under the sponsorship of the Bureau of Mines.

Diverse Applications

In another project, NBS built piezoelectric hydrophones for listening to sonar signals under water, an application that was funded by the Navy. Similar units could be made up as arrays and used for finding fish or for underwater geophysical exploration.

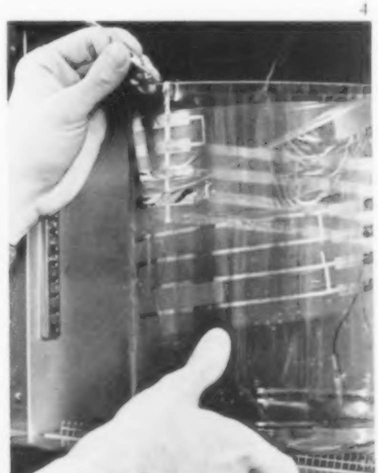
Two recent projects are a further indication of the range of applications for piezoelectric polymers. NBS is working on gages for the Department of Treasury to be used on the presses that print U.S. currency. The Treasury Department needs a built-in gage to monitor pressure on the presses that operate at very high speeds. Precise pressure is needed to maintain quality control. Piezoelectric polymer sensors, which can be cut to nearly any shape, could do this very well. And in a project for the Bureau of Radiological Health of the Food and Drug Administration, NBS is working on polymer dosimeters for studies of ultrasonics used in diagnosis and treatment.

The list of potential applications runs to pages, but whatever the application, the key point, Edelman says, is that with piezoelectric polymers, "it is possible to design the measuring instrument to be suitable for the conditions under which the measurement is made, rather than try to adapt the conditions of the measurement to suit the needs of a conventional instrument designed to have general utility."

turn page

3

4



5

To make piezoelectric polymers, physicist Steve Roth positions a film of poly (vinylidene fluoride) front of a mask to allow metal to be deposited (1). Film is placed in an evaporator to form metallic electrodes (2), then moved to an oven (3) where electrical leads are attached (4). The temperature is raised to 80 °C and an electrical field is applied. Finished devices (5) will be used a pressure gages on printing presses for the Treasury Department.

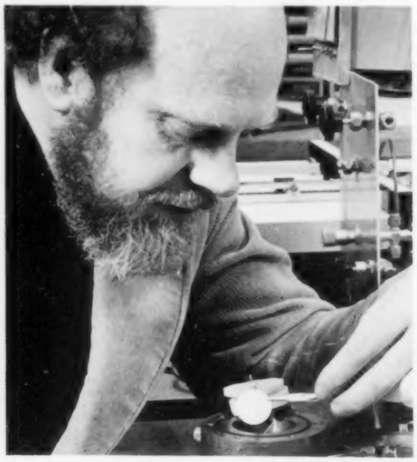
Fundamental Research

Research on the theory of piezoelectric polymers has gone hand in hand at NBS with applications work. Martin Broadhurst, chief of the Bulk Properties Section in the Polymers Division, explains that, "the objective of our research on the fundamentals of piezoelectricity in polymers is to understand the mechanism responsible for the effect and identify the polymer properties that affect it. Despite the fact that this effect has been known for many years, there is still controversy over the physical phenomenon responsible for it. With information gained from our studies, we should be able to select the best polymers and to optimize the conditions for introducing and maintaining the piezoelectric activity."

Basically, there are two schools of thought to explain the phenomenon in polymers, Broadhurst notes. The first can be called the "molecular dipole model;" the second is known as the "trapped space charge model" (see box). Research at NBS has been aimed at building a model to explain piezoelectricity in polymers, making predictions based on the model, obtaining experimental data, and comparing predictions with actual behavior.

Considerable data are required on the molecular and bulk structure and properties of polymers. X-ray, infrared, and Raman spectroscopy are among the tools used to determine molecular orientation and structure in the polymers. These studies are complicated because PVDF contains a mixture of as many as three crystal phases dispersed in a large fraction of supercooled liquid phase. Two of the crystal phases are polar (molecular dipoles are parallel) and ferroelectric (dipole direction can be changed with an electric field). One surprise is that the third, antipolar crystal phase can also be made piezoelectrically active. This is apparently due to a field-induced crystal transformation, which is currently being characterized at NBS. This finding is important because the antipolar phase is the most common crystal form. The ability to make it piezoelectric greatly expands the potential applications of PVDF.

In another series of experiments, the piezoelectric and pyroelectric responses of polymers are measured concurrently using a special cell. Results of NBS research show that both effects arise from a common source—volume changes in the polar crystals produced by mechanical stress or temperature changes. In these experiments, special techniques were developed to measure the compressibility and thermal expansion of thin (around 10 micrometers) polymer films with a sensitivity of 10^{-12} meters.



Martin Broadhurst places polymer transducer into a cell for measuring piezoelectric and pyroelectric constants.

Tom Davis points to an x-ray scan of a piezoelectric polymer before and after poling. Peaks in the foreground on the scan are missing after poling, indicating that a change in crystal structure has taken place.

Model Predictions

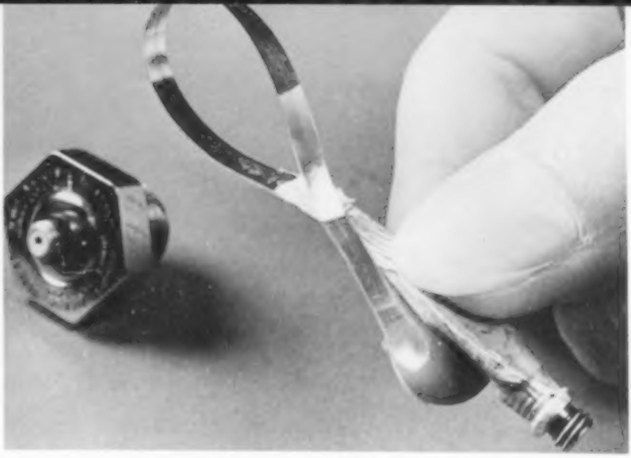
Another set of experiments was designed to test a prediction of the model. According to the theory, chains twisted during poling will tend to untwist and thus shorten the lifetime of the polymer devices. Stability of piezoelectric polymers is a problem of primary concern to users of the films. To test this idea, PVDF was crystallized in the presence of an electric field. The resulting samples had greatly enhanced stability. This information should be useful in optimizing performance of the films.

Measuring the charge distribution in polymer films is also important for understanding their performance. In 1976, an Australian scientist, Dr. R. E. Collins of AWA Research Laboratory, worked with NBS scientists. During his stay, he set up an apparatus for measuring charge distribution. The method relies on the nonuniform thermal expansion of a film following a short heat pulse. The resulting electrical signal depends on the distribution of charges in the film. These "thermal pulse experiments" are continuing and are yielding a great deal of information on the uniformity of polarization and the field distribution during poling.

In still other experiments, NBS scientists use a plasma (ionized gas) to generate poling fields large enough to induce piezoelectricity even at room temperature. These experiments and others to date have provided much evidence to support the molecular dipole theory, according to Broadhurst. He believes that such advances in the theory will help scientists understand not only the phenomenon behind the effect, but also establish how much better the films can be.

Broadhurst notes that much more needs to be understood about the behavior and phenomenon behind piezoelectric polymers. But without waiting for theory to catch up to applications, industry is already using the materials in an increasing number of ways. Of the many transducer manufacturers who have come to NBS to learn about this new technology, several have developed commercial applications. "Transferring our know-how to industry and other agency labs has been a primary goal of our work," Broadhurst says.

Scientists involved in the research believe that someday piezoelectric devices made from polymers will be as commonplace as the plastic wraps found in nearly every household. Says Edelman of the outlook for piezoelectric polymers, "Some day, the applications of piezoelectric polymers will be limited only by the imagination of the user." □



The advantage of piezoelectric polymer transducers over conventional ceramic devices is illustrated dramatically in this photo. The polymer device is not only flexible, but weighs a mere .3 milligram (without the metal lead) compared to the ceramic device which weighs about 21 grams.

TWO THEORIES
VIE TO EXPLAIN
PIEZOELECTRICITY IN POLYMERS

Currently, there are two schools of thought to explain the phenomenon of piezoelectricity—the molecular dipole model and the trapped space charge model. These are highly complicated mathematical theories. The explanations below are simplified explanations.

Molecular dipole model

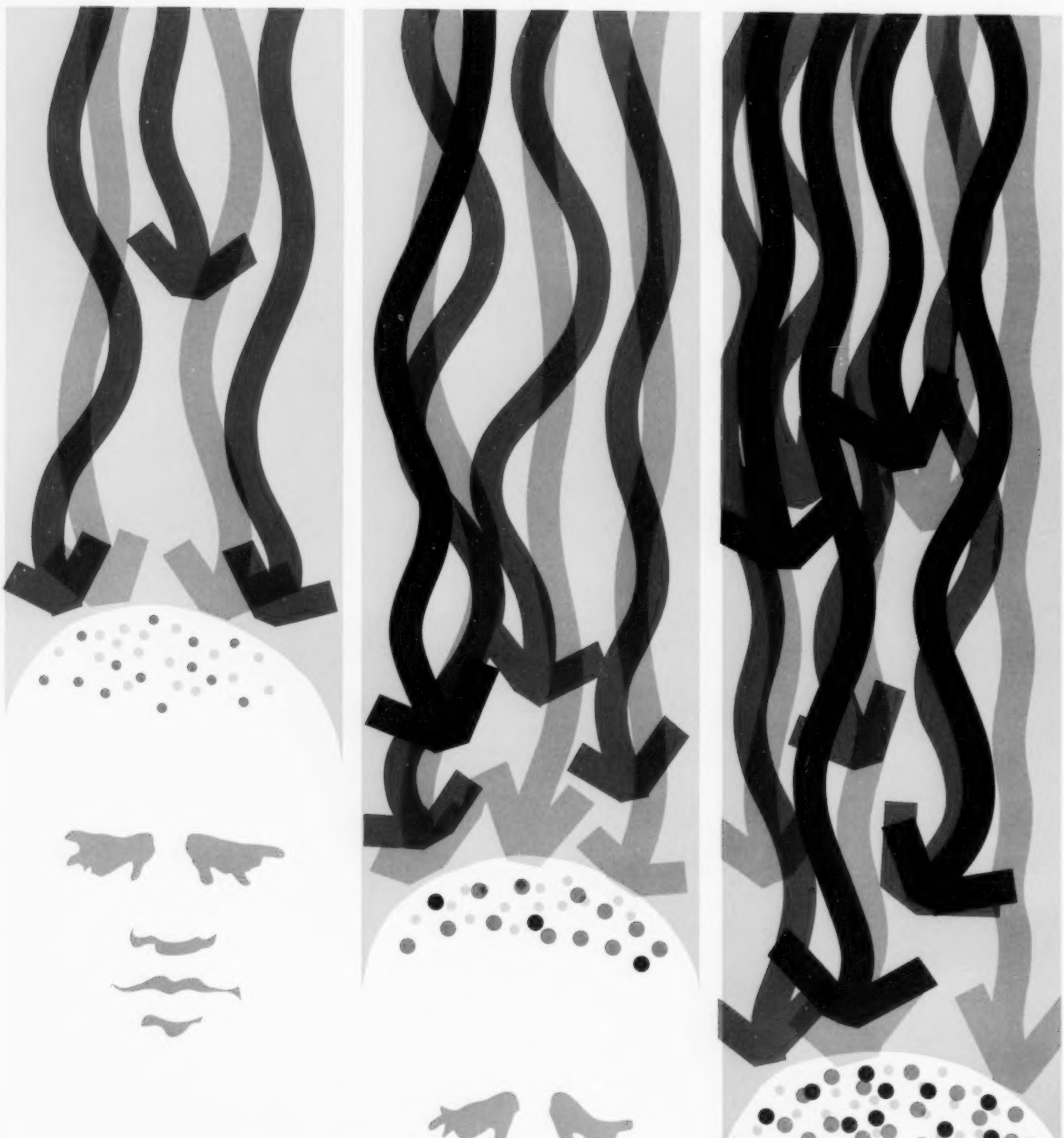
This model explains piezoelectric behavior in two types of polymers—amorphous and semi-crystalline. Polymer molecules are made of polar subunits called dipoles, which line up in an electric field like magnets in a magnetic field. Usually these dipoles are randomly oriented and can not produce piezoelectricity. If the dipoles can be oriented in one direction with an electric field and the orientation can be frozen (by cooling below the glass transition temperature in the case of amorphous polymers or by producing a polar crystal phase in the case of semi-crystalline polymers), then the polymers will be piezoelectric. That is, the surface charge on a poled film will depend on the net dipole moment divided by the film volume. The volume changes whenever the sample is stressed and induces charges on the film surface. The larger the dipoles and the more complete the alignment, the more active the film will be.

Trapped Charge Theory

This school of thought rejects the explanation that the aligning of dipoles is the basis for the piezoelectric responses of polymers. Instead, real charges in the material are trapped in certain polymer sites and it is these charges that respond to the electric field, according to this idea.

For more information about piezoelectric polymers, write to Dr. Martin Broadhurst, Polymers Building, Room B 324, National Bureau of Standards, Washington, D.C. 20234.

Dynamics of



Information Systems & Users

by Stephen A. Rossmassler

THAT old philosopher Dr. Johann Faust suffered the boredom that evidently comes when one has mastered all the provinces of knowledge. Consequently, he sold his soul to the devil in return for pleasures and powers that knowledge could not provide. Trading with the devil may not be as popular today as it was in the Middle Ages, possibly because people can no longer aspire to the mastery of all knowledge; therefore they never get as bored as Faust.

On the other hand, the growing span of human knowledge has led to greater and greater specialization in learning and to such proliferation of information that sorting and selecting it grows difficult. So, the human race becomes collectively more knowledgeable, and the individual gets relatively more ignorant.

To save ourselves from ignorance, we have become a society replete with *information systems.* They enable us to carry on our daily activities from the mundane to the esoteric. For example, if you want to talk to your supplier of frammistans in the next town, or your aunt in the next state, you use the telephone number information system to find the right number. As far as you are concerned, the system consists of the printed directories, your own hand-written list of numbers, and the directory assistance service (dial 411). Your entry is your identification of a person or organization; the system's response is a telephone number. Note that the system output is precisely formatted for your use—once you get the number, you can dial without any interpreting or restructuring.

The weather information system is another system you use regularly. In comparison with the telephone system, the weather system contains data which are much more scientific and technical, and it uses a variety of sophisticated interfaces with the users. You can get your weather data and forecasts from the newspaper, by telephone, or through the TV broadcasts. They are disseminated in carefully planned, user-oriented packages which make most user-system interactions unnecessary.

Dr. Rossmassler is area program manager, materials utilization data, Office of Standard Reference Data. A physical chemist by training, Rossmassler has worked on the problems associated with technical information since 1954. His perspective on the subject is based on experience within an industrial corporation, a nonprofit advisory organization, a federal agency in the executive branch of government, and an office of the U.S. Congress.

Other information systems which you may use frequently include ones for highway information, stock market information, and entertainment availability information. You may never have considered calling them information systems. To you they merely may be effective ways of finding out what you need to know. In fact information systems are essential to the way we live.

Information flow is, of course, a fundamental element of any society. The more advanced and complex the society, the greater is the need for effective channels through which information can flow to all users. The stronger the technological base, the greater is the scientific and technical content of the information which must flow.

The United States economy has a large technological component, and therefore we have great need for scientific and technical information. Moreover, the United States is, in terms of the analysis of Daniel Bell and others, a "postindustrial nation, in that the majority of the labor force today is not engaged either in agriculture and extractive industries, or manufacturing industries, or a combination of both, but essentially in services—that is, trade, finance, real estate, education, research, administration, government. . . . A postindustrial society is organized around information and utilization of information in complex systems, and the use of that information as a way of guiding the society." (1).

If the society we live in is organized around information, we need at least a minimal understanding of information, information systems, the application of information, and the relationships between information users and the systems which supply them. That understanding should extend specifically to *scientific and technical* information systems. Why? One reason is the increasing need for reliable data that comes with the growing sophistication of science and technology. If your telephone information system feeds you a wrong number, that is a nuisance. But the designer of a heart pacemaker or a nuclear reactor cannot afford much of a margin of error. The same is true in many areas where good science can be undermined by faulty data.

The problem is further complicated by the very nature of modern information systems. A scholar

turn page

[1] Bell, Daniel. "Remarks of the Moderator," pp. 13-15 in *The Management of Information and Knowledge.* Washington, DC: Superintendent of Documents, U.S. Government Printing Office, 1970.

COVER STORY

laboring in a library can exercise independent judgment about the validity and reliability of the information he is gathering. But a researcher consulting a computer for a particular number receives data disconnected from their source and rendered seemingly authoritative by the complexity of the surrounding machinery.

To save themselves from the fate of being misinformed—which can be much worse than the fate of being uninformed—users of scientific and technical information systems need data of known reliability. This is only one point in understanding the dynamics of information users and systems.

With the objective of developing such an understanding, I would like to state eleven propositions about information and information systems. There is no attempt to prove the truth of these propositions, but you will find reference to sources where some of them are discussed in detail. I will expand on several with regard to particular systems.

Perhaps some readers, more expert than I about many aspects of information systems, may be stimulated to examine, endorse, challenge, or modify these propositions and add to the list. In that sense, I hope that this short paper will begin a dialog which will make you—and me—more effective users of information and information systems.

First proposition. The greatest practical benefit of information to a user is the increase it brings in his ability to define, understand, and solve his problems promptly and effectively.

Second Proposition. The greatest cost of information to a user is the amount of attention it demands of him. Another statement of this proposition has been given by Weinberg (2, page 13): ". . . the capacity of the user to absorb information limits the system."

This proposition brings up the "information explosion," and the 7 percent growth rate of the scientific and technical literature which has been going on since about 1950. Seven percent growth per year is not really an explosion, but it does extrapolate to uncomfortable situations, some which are already occurring.

The statement of this proposition also provides an opportunity for quoting the most picturesque

[2] *Science, Government and Information. The Responsibilities of the Technical Community and the Government in the Transfer of Information.* A Report of the President's Science Advisory Committee, Washington, DC: Superintendent of Documents, U.S. Government Printing Office.

description I know of the plight of the average user of scientific and technical information. During a public discussion of the SATCOM report (3) in 1969, Jordan Baruch, then president of EDUCOM, remarked, "I cannot drink from your firehose."

Simon (4) has analyzed this issue with regard to information in general. His discussion includes its application to information systems, leading to a principle which I have taken the liberty of paraphrasing as follows:

Third proposition. A satisfactory information delivery mechanism will withhold more information than it delivers. In particular, it will deliver relevant and reliable information, while holding back irrelevant and less reliable information.

This proposition implies an active and intelligent role for the mechanism, with a positive concern for the user's real information needs, expressed through selection of only a fraction of the total holdings. The information delivered to the user takes on added value through the selection process. Selection can occur at the level of integral works (books,

[3] *Scientific and Technical Communication. A Pressing National Problem and Recommendations for Its Solution.* Washington, DC: National Academy of Sciences, 1969.

[4] Simon, Herbert A. "Designing Organizations for an Information-Rich World." Chapter 2 of Greenberger, M., ed., *Computers, Communications and the Public Interest.* Baltimore: Johns Hopkins University Press, 1971.

scientific papers, reports, etc.) as prepared by their originator. Many good libraries offer such selection as a service feature.

In a more advanced form it is practiced by computer-based bibliographic services which offer searching (often interactive) of large data bases covering portions of the scientific literature. Document selection adds value to information, but still requires that the user find and extract from the document the specific bits of information which really meet his needs. If he is solving a scientific problem, for example, or needs data to design a piece of apparatus, he cannot substitute the document in his equations. He must locate the quantitative data which match the problem.

Another, more sophisticated kind of selection is available: the work of information analysis and evaluation, as practiced by Data Centers, or Information Analysis Centers. Weinberg, in the report already cited, describes the functions of the specialized information center which "makes it its business to know everything that is being published in a special field . . . it collates and reviews the data, and provides . . . compilations, critical reviews, specialized bibliographies, and other such tools." (5) Such centers perform systematically and expertly the tasks which the previous paragraph indicated as being left to the user. Data Centers not only select for relevance, but evaluate for reliability. Thus they add greatly to the value of the information the user receives.

Not all information systems make provision for data evaluation, which is an expensive and time-consuming process only justifiable when users really need it. Data evaluation is most frequent in scientific and technical information systems, such as the National Bureau of Standards' National Standard Reference Data System (NSRDS), and the nuclear data system started by the Atomic Energy Commission and carried on by the Energy Research and Development Administration and the Department of Energy. Data evaluation can be performed effectively in science and engineering because there are basic principles and laws which give coherence to the data in these fields.

turn page

[5] Weinberg, *loc. cit.*, p. 32.

The experience of NSRDS indicates that in a typical scientific area, a comprehensive data evaluation program can be undertaken at an annual cost of about 1 or 2 percent of the investment in ongoing research in that subject. (Catching up on a 5-year to 20-year backlog of unevaluated past publications may add another 2 percent for a few years.) But the value added to the information for the user in solving his problems may be 10, 20, or even 100 times the cost of the evaluation program.

The consideration of information evaluation and data centers has led us to the matter of specialization in information systems, and to the next proposition.

Fourth proposition. In a complex technological society, facing a wide range of problems, and involving a variety of problem solvers, no single information system can meet all the different needs of all users. An effective information system must be designed and operated to meet the specialized needs of a specific community of users.

Clearly, the stock-market quote system could not be adapted to the needs of aeronautical design engineers; if it were, it would no longer be useful on Wall Street. It would probably be impossible (and surely very costly) to develop an information system for all of science. A single system for chemistry, another for physics, another for metallurgy, may be feasible. Practical experience in the National Standard Reference Data System indicates that modest beginnings and thoughtfully planned growth provide a good foundation for the development of a technical information system. This experience is expressed in the next two propositions.

Fifth proposition. An effective technical information system develops through continuing association with a primary, but not necessarily static, user community which supports the system intellectually and (at least to some extent) financially. Secondary user groups can be accommodated, but the needs of the primary users must come first.

Sixth proposition. In most cases, starting small and expanding in response to needs expressed by a primary user community means healthy growth. (Obviously this proposition does not apply to many military information systems, flight control systems, or others which are designed for specific operation and control situations.)

The point here is that we don't really know enough yet to base the design of technical information systems on assumed needs of hypothetical users. The priority list of problems keeps changing, and flexibility is essential. Another aspect of this situation is stated in the next proposition.

Seventh proposition. Users of information systems don't know in advance what new system capabilities or what additional resources they need.

When surveyed, information users generally say that the ideal information system would be one which would provide the same services they now get, but faster, cheaper, and more completely. Users tend to be quite modest in their demands. The system must educate the users about the possibility of totally new services, at the same time that the user is guiding the system.

The previous two propositions also apply to a most important aspect of the design of information systems—use of computers.

Eighth proposition. Many of the things that information systems do without computers, can be done at least as well and probably better with computers, but computerization should be based on practical experience.

Until the people in the system start doing their job, they won't know what computer capabilities they need in order to serve their users, or how their users will respond to the services they offer.

The next aspect of the growth of information services to be examined goes back to the sixth proposition. It involves the need for proper planning and flexibility in development and growth.

Ninth proposition. Regardless of size, an information system must exercise foresight and must plan its development to meet not only the present but also the future needs of its primary user community.

Obviously, starting small implies planned development and growth. If an information system promises to provide a range of needed services, and then gets into a situation where over half of the legitimate user inquiries are answered with "we cannot help you," it will frustrate even its most enthusiastic supporters. More to the point, it will not be able to maximize the added value inherent in the selection and evaluation processes discussed earlier, because it will not be able to build user confidence. Therefore, accurate planning for development is essential.

Having devised an accurate plan for its future, the system must implement the plan in a timely man-

ner. Information services cannot be created overnight. For example, new data evaluation projects in the NSRDS require several months to a year before they start producing useful output. Once a data center has established a strong base of expertise and a core file of evaluated data, it can respond rapidly and flexibly to unforeseen new requirements as well as to anticipated needs. Data centers in the NSRDS have repeatedly shown that they can assemble special-purpose data packages in one-third or less the time that would be necessary when starting from scratch.

Such flexibility is especially valuable in responding to urgent needs of important national problem areas—environmental quality, energy resources, and materials performance. These problem areas are largely technological in nature, and substantial scientific and technological advances are needed if we are to solve them. But at the same time, the problems do not fall into the existing categories of scientific disciplines—organic chemistry, metallurgy, nuclear physics, and so on. This situation leads to the next proposition.

Tenth proposition. Problems of national concern today are interdisciplinary in nature. They transcend the boundaries of existing information resources and require information and data from a variety of specialized scientific and technical areas. The information used by the interdisciplinary groups which are attacking these problems should be reliable and easily accessible, and the supply of information must adequately cover the subjects.

Interdisciplinary groups face difficulties which do not worry workers within their own specialty. Technical vocabularies are not common to all the groups, and the workers don't always know how to incorporate each other's expertise into their own efforts. In addition, they cannot tell, from their own experience, which data are reliable, and which are not. So they must have assurance from the start that they have a common foundation of facts—that is, data—on which to build.

Having looked briefly at a number of propositions concerning information and information systems, having suggested that information systems must be specialized in scope, and having expressed some concern about how these systems can grow, I must acknowledge concern about what will happen in the future, when dozens of specialized information systems are all growing vigorously in logical directions. At what point will they start to intersect? How will we avoid enormous confusion, and expensive redundancy?

Eleventh proposition. While the scope and growth pattern of specialized information systems should be related to the needs of their users, there should be a logical framework within which these systems can relate to one another and avoid duplication of effort.

This framework should also be visible to all the present and potential users of the various systems, so that they can understand where to go for what kind of information, and not get lost.

The nature of the framework I propose, the question of who might be responsible for providing and maintaining it, and the amount of authority which that person or organization will wield, are matters of theoretical and practical importance. I hope that after several other authors have joined in this dialog, we will have brought together enough expert understanding to permit us to deal with this final proposition in the depth it deserves. □

BOTTLE SAFETY NOW THE SUBJECT OF TWO VOLUNTARY STANDARDS

by David Chaffee

Carbonated soft drink bottles, already the object of one completed Voluntary Product Standard (VPS),* will now become the focus of a second, additional voluntary standard. The completed VPS recommends standards for the manufacturers of carbonated soft drink bottles while the second VPS—now in its initial stage—will establish guidelines for distributors of bottled carbonated soft drinks.

Both standards are aimed at reducing the numerous bottle-related injuries that occur each year. For example, an estimated 32 000 such injuries took place in 1976. Both standards are concerned solely with the conventional returnable and nonreturnable glass bottles manufactured from soda-lime-silica glass, but are not applicable to plastic-clad or encapsulated bottles. Both standards are based on technical information from the same groups of manufacturers, distributors and consumers.

"The standard we have just started to work on will address the handling procedures that distributors employ before products are sold on the market. It will cover work done at the plant, including capping and handling," says Karl Newell, chief of the Standards Development Services Section.

NBS's role is to coordinate such voluntary standards, offer technical advice to the Standard Review Committee, and publish the approved standard. In the case of the VPS under development, the NBS Standards Impact Analysis Program will try to determine areas were economic analysis might be useful in setting bottle requirements, and if time and resources permit, will assist in making such analyses. This effort will mark the first time SIA has become involved in the Voluntary Product Standards process.

The first VPS for bottle manufacturers, recently approved by NBS Director Ernest Ambler, contains requirements for thermal shock resistance, internal pressure strength, temper number, abrasion resistances, simulated impact resistance, wall thickness, dimensions and weights, and bottle identification marks. It also describes test procedures which can be used to determine whether soft drink bottles conform to the standard.

In processing that VPS, NBS sent the completed standard to producers, distributors, and consumers for their acceptance. Ninety-six percent of the producers, 98 percent of the distributors and 90 percent of the consumers responding were in favor of the standard. Included among the 3000 groups or individuals who reviewed the standard were the Good Housekeeping Institute, the National Soft Drink Association, Consumers Union, the Center for Concerned Engineering, and the Glass Packaging Institute.

"Under this voluntary standard, soft drink bottles will be subjected to additional rigorous inspection designed to increase the safety of the product," says William W. Sadd, President of the Glass Packaging Institute. Sadd explains, "Bottles have been subjected to testing procedures for years, but today's voluntary standard represents an improvement in the state of the art."

Chaffee is a staff writer for DIMENSIONS/NBS.

*To order, write Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 and ask for PS 73-77. Price: 80 cents.

STAFF REPORTS

NEW TECHNIQUES IN THE MEASUREMENT OF CATALYTIC ACTIVITY

The use of ultrahigh vacuum surface cleaning procedures has revealed previously unsuspected catalytic activity of tungsten and rhenium for the synthesis of methane from hydrogen and carbon monoxide. These results have significance in the production of synthetic natural gas and other chemicals following the gasification of coal.

Richard D. Kelley and Theodore E. Madey, Physical Chemistry Division, B248 Chemistry Building, 301/921-2188.

Heterogeneous catalysis is a vast field which contributes directly or indirectly to a large fraction of the U.S. GNP. Research in catalysis over the past fifty years has for the most part been directed toward an understanding of the physical and chemical processes which occur on the surface of a catalytically active metal. Most of this work has been hampered by the inability to adequately characterize catalyst surfaces.

In recent years, techniques in surface physics, utilizing ultrahigh vacuum, have advanced to the point that accurate and reproducible elemental analysis of catalytically active surfaces is possible. However, the surface physics techniques require a vacuum of $\sim 10^{-10}$ Torr (13×10^{-9} Pa) and crystalline samples with ~ 1 cm^2 of surface area, while traditional catalytic studies require a gas pressure of $\sim 10^3$ Torr (13×10^4 Pa) and powdered or supported samples having total surface areas of ~ 100 m^2 per gram. The merging of these techniques has obvious technical problems which have now been solved in a few laboratories.

The following example demonstrates the relationship between surface composition and catalytic activity and the value of the surface physics approach to catalytic chemistry. This example is the recent finding that tungsten is an exceedingly active methanation catalyst. Methanation

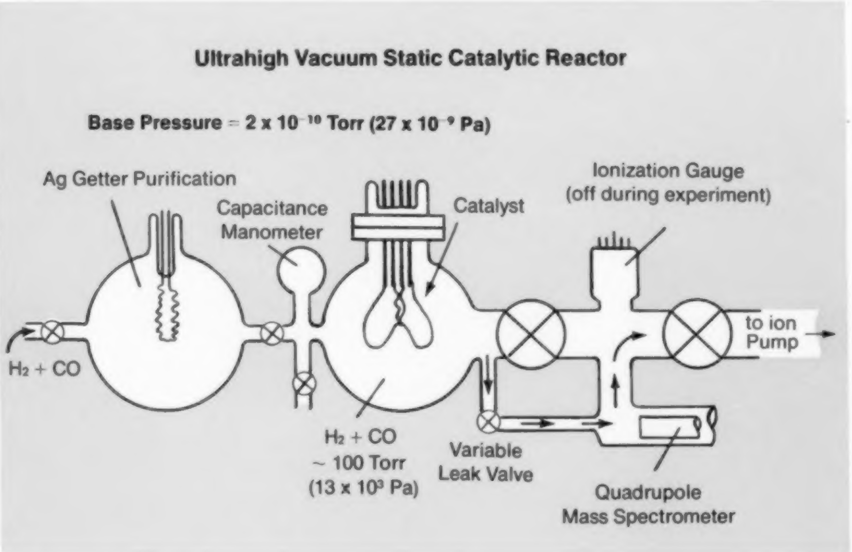


Figure 1—*Ultrahigh vacuum static catalytic reactor for study of the catalytic methanation reaction.*

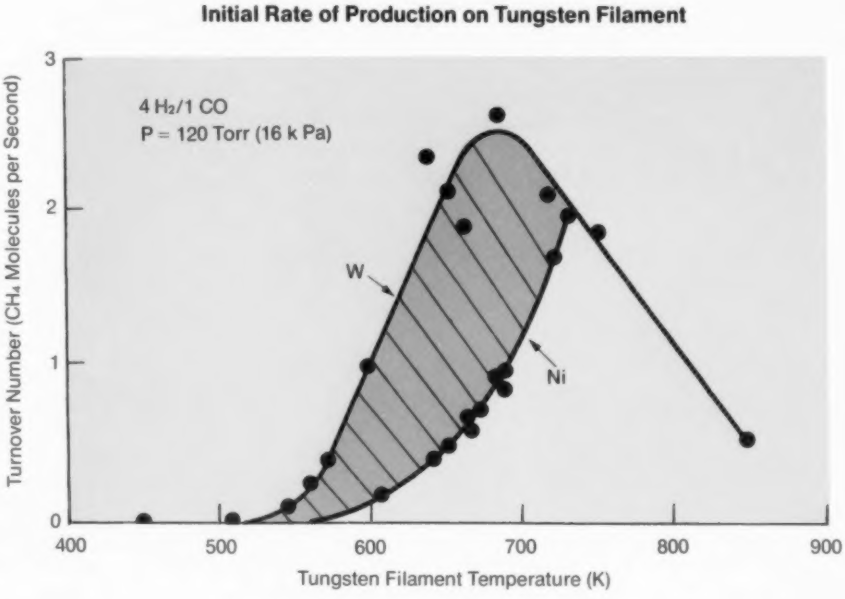


Figure 2—*Rate of CH_4 production on atomically clean tungsten and nickel catalysts.*

is the hydrogenation of carbon monoxide to methane ($3H_2 + CO \rightarrow CH_4 + H_2O$). The development of sulfur-resistant catalysts to promote the methanation reaction is of importance because of their use in the production of synthetic natural gas from sulfur-bearing coals. There is evidence that Mo and W catalysts may possess a significant tolerance to sulfur since these catalysts are often sulfided before use. However, compared to the useful methanation catalysts such as Ni and Ru, both supported Mo and W catalysts are reported to exhibit low catalytic activity.

A diagram of the apparatus used in these studies is shown in Figure 1. It is constructed mainly of glass with metal valves thoughout and contains a W filament of ~ 2 cm^2 geometrical area in the reactor bulb. The apparatus was processed by bakeout to achieve a base pressure of 2×10^{-10} Torr (27×10^{-9} Pa). $H_2 + CO$ gas mixture was stored over the Ag getter film as a precautionary purification procedure. Atomically clean tungsten was produced by repeated heating in oxygen at 10^{-7} Torr (13×10^{-6} Pa), followed by flashing to 2400 K in vacuo. After the introduction of 120 Torr (16×10^3 Pa) of the $H_2 + CO$ mixture, the tungsten wire was resistively heated to the reaction temperature. The rate of methane production was followed by sampling a minute quantity of the gas mixture with the quadrupole mass spectrometer.

Figure 2 shows the measured values of the specific rate of catalytic reaction as a function of the temperature of the W catalyst. For comparison, the specific rate for a Ni ribbon catalyst as measured in the same apparatus is also shown. These results demonstrate that over a wide temperature range, the activity of tungsten greatly exceeds that of Ni for the methanation reaction.

The key to the activity of tungsten for the methane synthesis seems to lie in its surface preparation and the level of surface impurities. Powered or supported W is difficult or impossible to clean by low temperature (< 1000 K) oxidation-reduction cycles. Even vacuum-evaporated films prepared under stringent conditions are often found to contain surface impurities. However, the surfaces of tungsten wires and ribbons can be made atomically clean in a reproducible fashion by high-temperature heating in an ultrahigh vacuum. In the present experiment, the use of ultrahigh vacuum surface-cleaning procedures and highly purified gases drastically reduced the possibility of surface contamination and permitted an accurate measure of the true activity of W as a methanation catalyst.

This work is continuing with studies of other refractory metals—rhenium, molybdenum, and tantalum. Preliminary results indicate that rhenium is considerably more active than tungsten for the methane synthesis. High surface area rhenium catalysts in reduced form have been recently reported. Thus, refractory metals and alloys containing refractories present intriguing catalytic possibilities.

NBS DETECTS MAGNETIC AUDITORY EVOKED RESPONSES

NBS reports the first observation of the magnetic auditory evoked response (MAER). The MAER is sharply localized over or near the auditory cortex of the human brain. Our observations, together with previous observations of visual and somatic responses, indicate that magnetic detection may be a unique tool for non-invasive mapping of a wide variety of brain functions. Observations were possible by application of a SQUID (superconducting quantum interference device) as a gradiometer.

*James E. Zimmerman, Cryogenics Division, Room 2-2003B, Boulder, Colo. 303/499-1000, ext. 3901.**

Several laboratories have demonstrated that both visual and somatosensory magnetoencephalographic (MEG) averaged evoked responses are more localized in their scalp distribution than are their more conventional electroencephalography (EEG) counterparts. NBS has observed —and we present the first evidence of— MEG auditory evoked responses. Obtained data indicate that the responses are very localized in their scalp distribution, possibly accounting for the fact that they have remained undetected until present.

All recordings were performed at the National Bureau of Standards, in Boulder, Colorado on four male subjects. The magnetic detector was an asymmetric second-derivative SQUID gradiometer suspended in a liquid-helium-filled dewar. The lower gradiometer coil was 2 cm in diameter, oriented to be sensitive to magnetic field lines perpendicular to the scalp, but not parallel to the scalp. First and second-derivative gradiometers require less elaborate shielding than do magnetometers. Gradiometers are sensitive primarily to fields with relatively large gradients such as sources close to the device and not such as earth's magnetic field. The gradiometer used was suspended inside a room shielded with 4-cm thick seam-welded aluminum panels. The subjects were positioned beneath the gradiometer, the bottom coil of the gradiometer approximately 2 cm from the scalp.

One millisecond (ms) square wave pulp clicks were generated through a buffer amplifier to a small cone speaker located in a sound-proofed box outside the shielded room. A 4-m long 12-mm diameter plastic tube carried the sound stimulus from the speaker to the subject via an airline type plastic headset with two earpieces.

With a bandpass of 5-15 Hz, the raw MEG gradiometer output was amplified and displayed on a dual channel signal averager, triggered by the same pulse generator that produced the clicks. Clicks were delivered at 250-ms intervals, averaging time was 200 ms after such stimulus, and 512 stimuli were averaged in

turn page

*In collaboration with M. Reite, University of Colorado Medical Center, J. Edrich, University of Denver, and J. T. Zimmerman, University of Colorado, Department of Psychology, Boulder, Colo.

Figure 1—*Averaged magnetic auditory evoked response from two subjects with all tracks being 200 ms long and an average of 512 samples. Tracks 1 and 2 are consecutive averages from the right hemisphere of subject #1 Tracks 4 and 5 are consecutive averages from the left hemisphere of subject #2. Tracks 3 and 6 are control sample averages with no sound stimulus. The gradiometer in all cases was located slightly above and anterior to the T3 and T4 electrode placement (about point 3 in figure 2).*

each experiment. Sound transit time from the speaker to the subject was approximately 12 ms.

In all subjects, the gradiometer was positioned over the scalp area thought to correspond most closely to the primary auditory cortex on the superior aspect of the temporal lobe. This was slightly above and anterior to the standard T3 and T4 international 10-20 electrode placements. Recordings were made from left and right hemispheres in all subjects: more extensive mapping was performed in two subjects.

Definite MEG auditory averaged evoked responses were obtained in all subjects. Not all responses were the same, either between subjects, between hemispheres, or from one time to another in the same subject. Explanation for this apparent inconsistency follows in the test. The mapping studies demonstrated the magnetic evoked response to be quite localized, and to fall off rapidly in amplitude as the gradiometer was moved away in any direction from the primary placement.

In figure 1, the average magnetic evoked responses are recorded from the right hemisphere of subject number 1, and the left hemisphere of subject number 2. In both subjects, a downward deflection (indicating a field direction out of the scalp) is noted at about 55 to 60 ms, indicating a latency of 43 to 48 ms (taking into account the 12 ms sound transmission time). An upward deflection is noted between 110 and 130 ms (latency of 98 to 119 ms), indicating a field direction into the scalp. The largest evoked responses trace (No. 2) has a maximum peak-to-peak amplitude of about 1 picotesla.

Figures 2 and 3 illustrate the magnetic evoked response obtained by moving the gradiometer in different directions away from the primary placement. In figure 2, magnetic responses are not clearly separable from noise when the gradiometer is moved 4 cm anterior (track 1) or 4 cm posterior (track 5), although responses are detected at intermediate locations. In figure 3, a similar effect is noted, with the magnetic response essentially disappearing as one moves 5 cm above (track 1) or 6 cm below (track 4) the primary placement.

In three of the four subjects, the magnetic evoked response was of highest amplitude over the nondominate hemisphere; in the fourth subject the response was of equal amplitude over both hemispheres.

These data demonstrate that MEG evoked responses are produced by auditory stimuli, and that, like magnetic responses evoked by visual and somatosensory stimuli, they are of highest amplitude in the general region of the primary sensory cortex and may be undetectable a short distance away. In marked contrast, EEG average auditory evoked responses are widely distributed over almost all scalp regions. It appears that magnetic evoked responses in general are very different in their distribution from conventional EEG evoked responses. This difference is likely due, in part, to the fact that the strength of a magnetic field diminishes rapidly as the distance from the source increases. These facts likely account for the observation that magnetic averaged evoked responses are difficult to replicate with precision at different times in the same subjects. Due to their being highly localized, a very small change in the subject's position with respect to the gradiometer (1 cm) will likely influence the configuration of the response obtained. (This is also a function of the resolving power of the gradiometer).

The observation that magnetic evoked responses are quite localized in distribution suggests that they may prove to be very useful research tools. To date, the stimuli we used were not designed to have meaning to the subjects. It is possible, when meaningful stimuli are used, that more widespread areas of the cortex will become involved in their processing. Accordingly, it may then be possible to detect magnetic responses over these newly activated areas of the cortex. Of course, the same influences likely operate with respect to the MEG itself, and thus, in theory, MEG activities in general should be closely localized to the brain area responsible for producing the detectable response.

Figure 2—*Distribution of the left hemisphere magnetic auditory evoked response in the anterior-posterior direction in subject #3 is noted by the placement of the gradiometer over the five numbered locations. Samples represent 512 averages recorded. All tracks are 200 ms long. The approximate locations of the F7, T3 and T5 EEG electrode positions are indicated for reference.*

Figure 3—*Distribution of the left hemisphere magnetic auditory evoked response in the vertical direction in subject #3 is noted by the placement of the gradiometer over the five numbered locations. Samples represent 512 averages recorded. All tracks are 200 ms long. The approximate locations of the T3 and C3 EEG electrode positions are indicated for reference.*

ULTRAVIOLET PHOTOMETER FOR OZONE CALIBRATION

Researchers at the National Bureau of Standards have designed and constructed an ultraviolet photometer for calibrating atmospheric ozone monitors. UV absorption photometry is one of the methods being studied by the Environmental Protection Agency in an effort to find alternatives to the iodometric procedures currently specified by EPA for instrument calibration.

*Arnold M. Bass, Physical Chemistry Division, B162 Chemistry Building, 301/921-2711.**

The oxidation of iodide to iodine by ozone, in a properly prepared solution of potassium iodide, is the basis for the reference method specified by the Environmental Protection Agency for the calibration of atmospheric monitors. Recent comparative measurements [1] of the specific iodometric methods have raised serious doubts as to the accuracy and reproducibility of the iodometric calibration procedures. At the present time, the Environmental Protection Agency is considering two candidate methods: gas phase titration and ultraviolet photometry as replacements for the 1 percent neutral-buffered potassium iodide procedure which is the current Federal Reference Method for calibration of pollutant monitors.

In order to provide a facility at NBS for the measurement of ozone concentrations, independent of gas phase titration based on a nitric oxide standard, we decided to set up an ultraviolet photometer that would have the sensitivity required for ozone measurements at ambient concentrations. The performance desired of the photometer was a capability to measure ozone concentrations over the range 0.05 ∿ 1.0 ppm with an accuracy of at least 0.005 ppm over the entire range.

The photometric measurement method is based on the application and the validity of the Beer-Lambert Law:

where: $I = I_0 \exp \dfrac{-273\ cPkL}{10^6 T}$

c is given in ppm (parts per million by volume)

$k = 308.5\ cm^{-1}\ atm^{-1}$ (base e) is the ozone absorption coefficient [2] at 253.7 nm, 273 K, and 1 atmosphere

L is the path length, cm

P is the total pressure, atm.

T is the temperature of the cell, K

I/I_0 is the transmittance (Tr) of the sample.

The design of the photometer is based principally on the accuracy requirement, 10 percent at 0.05 ppm. The quantities, k, L, P, T appearing in the equation are all known or can be measured to within 1 or 2 percent. Thus the accuracy of the concentration measurement is mainly determined by the accuracy of the transmittance measurement. The error in the transmittance measurement may be expressed as

$$\frac{\Delta C}{C} = \frac{\Delta Tr}{Tr} \times \frac{1}{\ln Tr}$$

According to estimates, transmittance could be measured with a precision $\frac{\Delta Tr}{Tr}$ of about .0002 by using photon counting. These conditions imply a transmittance of 0.998 which can be achieved at the O_3 concentration of 0.05 ppm in the absorbing path of approximately 3 meters.

The design selected for the photometer is shown in Figure 1. We decided that a double-beam arrangement would provide greater precision in the measurement through elimination of the effect of variability of the UV source. The cells of the photometer are made of 1-1/2″-diameter pyrex pipe; teflon gaskets are used to make vacuum-tight seals for the fused silica windows. The light from a low pressure mercury discharge lamp is passed through a narrow-band interference filter in order to isolate the 253.7-nm emission line. The light is collimated by a fused silica lens and passed through a partially-transmitting neutral density filter which serves as a beam splitter. The two beams then travel through the two absorption cells. Adjustable aperture stops limit the diameter of the beams to ensure that there are no reflections from inner walls of the cells. The beams emerge from the cells and are recombined on the face of a photo-multiplier tube by another partially reflecting filter.

The differential UV absorption method of photometry adopted for O_3 concentration measurements requires the precise and accurate measurement of flux emerging from each cell. Photon counting techniques were chosen for these flux measurements, using a UV sensitive tube with excellent single photo-electron resolution. If such a tube (which must be properly selected) is cooled to about −20 °C, the dark count rate is a few counts per second. By using high-speed electronics and very precise timing methods, it is possible to obtain accurate and statistically well-characterized pulse counts which correspond to incident beam flux on the photo-multiplier. This method may be preferable to analog techniques that are more subject to instability, drift, and uncertain amounts of non-linearity.

The Hg vapor lamp is energized either by a 10-KHz square-wave power oscillator or by a 60-Hz high voltage transformer. Flux passing through each sample cell is alternately allowed to fall on the photomultiplier by means of a light chopper. A chopper-blade with a single hole is driven by a hysteresis synchronous motor at a preselected rate—chosen to be unrelated to any harmonic or subharmonic of the line frequency. Light emitting diode-photo-transistor pairs are used to sense the position of the chopper; the signal from the phototransistor triggers a discriminator to start the timing and counting cycle for each sample tube.

A logic system, triggered by the discriminators, controls the pulse counters associated with each sample tube. To ensure precise counting times as the photomultiplier is exposed to each tube, an electronic gate is used so that the photomultiplier is fully (and not merely partly)

*Other researchers collaborating in this effort are Albert E. Ledford and Julian K. Whittaker, both of NBS.

exposed to the beam passing through the sample.

The photo-multiplier tube which must be selected for gain, low dark count rate and, most importantly, negligible after-pulsing, detects the photons as they arrive. This type of tube, with outstandingly good single photon resolution, is essential for this measurement.

The pulse output from the photomultiplier is amplified 100 times by direct-coupled amplifiers and the pulses are detected by a high speed pulse amplitude discriminator. Pulse counting is performed by conventional 100-MHz pulse counters and a rough guide of overall pulse rate is provided by a rate meter.

Counting time is determined by a pre-set counter which counts the revolutions of the chopper blade past the LED photo-transistor pairs. At the end of a counting interval, the results are printed out and the sequence repeats.

House air, dried and filtered, flows through one cell ("reference cell"), then into an ozone generator [3] from which ozonized air flows through the second cell ("sample cell"). The measurement is made by comparing the ratio of the signals transmitted by the two cells in the presence and in the absence of ozone. This provides the transmittance ($TR = \frac{I}{I_0}$), and the ozone concentration is determined by application of the Beer-Lambert Law already discussed. Since the mercury lamp is viewed, nearly simultaneously, through both cells, fluctuations in lamp intensity do not affect the measurement. Any impurities present in the air stream will be observed in both cells and will not interfere with the O_3 determination.

The performance of the photometer has been determined over the ozone concentration range 0.025 to 10.0 ppm. In order to compare the photometer with the other methods of calibration, a Dasibi commercial photometer was calibrated against the NBS laboratory photometer. The Dasibi instrument then served as a transfer standard for interconnecting the measurements made by the different

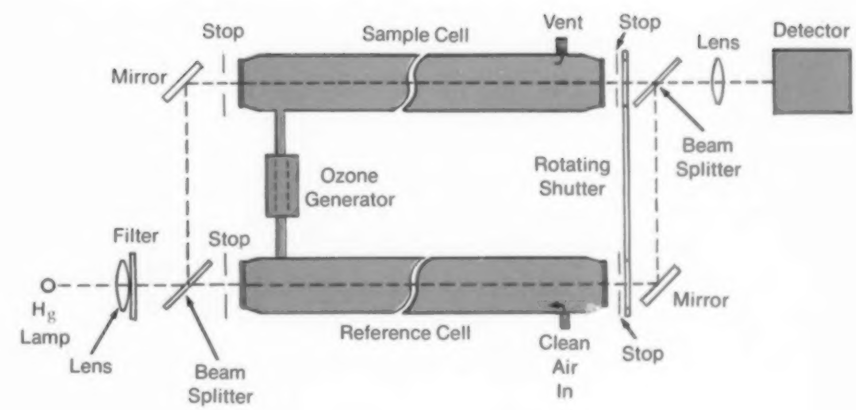


Figure 1—*Schematic of NBS ultraviolet photometer.*

methodologies in different laboratories.

Multiple analyses were made at several concentrations, and a linear regression analysis of the averaged data can be written as:

$$(O_3)_{UV} = (1.020 \pm 0.004)\ (O_3)_{DAS} - (0.001 \pm 0.002)$$

For additional comparative data, the NBS Dasibi instrument was transported to the EPA Research Triangle Park Facility. Dr. J. A. Hodgeson, of the NBS Office of Air and Water Measurement, made simultaneous O_3 comparisons at the EPA Environmental Monitoring and Support Laboratory, where concurrent evaluations of the gas phase titration method and a modified Dasibi photometer [4] were being performed. From these measurements the following relationships were obtained:

$$(O_3)_{GPT,\ EPA} = (1.01 \pm 0.02)\ (O_3)\ UV,\ NBS + (0.011 \pm 0.003)$$

$$(O_3)_{UV,\ EPA} = (0.98 \pm 0.01)\ (O_3)\ UV,\ NBS$$

Thus, the agreement between UV photometric and gas phase titration measurements is excellent. Comparisons between UV photometry and iodometry, using either neutral phosphate buffered KI or boric acid buffered KI, show a much larger discrepancy. This discrepancy is currently being examined in detail.

REFERENCES

1. (a) "Comparison of Oxidant Calibration Procedures," report of the Ad Hoc Oxidant Measurement Committee of the California Air Resources Board, Sacramento, CA (20 Feb. 1974).
(b) "Interagency Comparison of Iodometric Methods for Ozone Determination," W. B. DeMore, J. C. Romanovsky, M. Fieldstein, W. J. Hamming, and P. K. Mueller, in "Calibration in Air Monitoring," ASTM Special Tech. Publ. 598, pp. 131-143 (Philadelphia, 1976).
2. The value of k used in this work (308.5 cm^{-1} atm^{-1}) is based on an evalution by R. Hampson and D. Garvin of measurements reported in the published literature: (a) Inn, E. C. Y. and Y. Tanaka, J. Opt. Soc. Am. *43*, 870 (1953).
(b) Hearn, A. G., Proc. Phys. Soc. *78*, 932 (1961).
(c) DeMore, W. B. and O. Raper, J. Phys. Chem. *68*, 412 (1964).
(d) Griggs, M., J. Chem. Phys. *49*, 857 (1968).
(e) Simons, J. W., R. J. Paur, H. A. Webster and E. J. Blair, J. Chem. Phys. *59*, 1203 (1973).
(f) Becker, K. H., U. Schurath, and H. Seitz, Int. J. Chem. Kinet. *6* 725 (1974).
3. Hodgeson, J. A., R. K. Stevens, and B. E. Martin, ISA Trans. *11*, 161 (1972).
4. Paur, R. J., R. E. Baumgardner, W. A. McClenny, and R. K. Stevens, "Status of Methods for the Calibration of O_3 Monitors", Extended Abstract presented before the Division of Environmental Chemistry, ACS Meeting, April 1976, New York.

CONFERENCES

For general information on NBS conferences, contact Sara Torrence, NBS Office of Information Activities, Washington, D.C. 20234, 301/921-2721.

10TH MATERIALS RESEARCH SYMPOSIUM

The 10th Materials Research Symposium: Characterization of High Temperature Vapors in Gases will be held on September 18-22, 1978, at NBS headquarters in Gaithersburg, Md.

Papers are now being solicited for a major conference on the state-of-the-art and future directions of characterization methods for high temperature vapors to be held next year at the National Bureau of Standards.

Modern technology increasingly requires materials and processes to function at high temperatures—a condition where the vapor, gaseous or plasma phase becomes significant. For example, the future success of new energy technologies such as coal-fired magnetohydrodynamic (MHD) generators, coal gasification and nuclear fusion depends largely on materials performance in hot, chemically reactive gaseous atmospheres. Characterization of such atmospheres and their components is a challenging problem requiring adaptation of existing techniques and development of new experimental and theoretical methods.

An assessment of these techniques for application in modern science and technology has not been previously attempted. The 10th Materials Research Symposium will address this question by assembling internationally recognized experts in the measurement science and technology of high temperature vapors, gases, flames and plasmas. Contributed papers will also be considered.

Examples of the topics to be covered in this symposium are:

- Classical species characterization techniques, e.g., Knudsen effusion, Langmuir vaporization, transpiration, and mass spectrometry.
- Spectroscopic diagnostic techniques, e.g., infrared, electron diffraction, matrix isolation laser Raman, and other modern spectroscopic methods.
- Temperature measurement.
- Thermodynamic equilibrium modeling.
- Gas kinetic modeling.
- Basic data—status and needs.
- Applications, e.g., MHD, CVD, lamps, fire side corrosion, flame inhibition, and enhancement.

Persons interested in submitting additional topic ideas should send them to Dr. John Hastie, A307 Materials Building, 301/921-2859, by Feb. 1, 1978. Persons interested in submitting abstracts in the above topic areas or additional areas should send abstracts of 200 words prior to Feb. 1, 1978 to Dr. Hastie.

The symposium is sponsored by the NBS Institute for Materials Research which sponsored the first Materials Research Symposium in 1966. Many thousands of scientists from the United States and abroad have attended the meetings which have covered topics such as analytical chemistry and environmental measurement.

CALL FOR PAPERS ANNOUNCED FOR THE FOURTH AMERICAN CONFERENCE ON CRYSTAL GROWTH

Papers are now being solicited for the Fourth American Conference on Crystal Growth to be held July 16-20, 1978, at the National Bureau of Standards in Gaithersburg, MD.

Sponsored by NBS and the American Association for Crystal Growth the meeting will provide a forum for exchanging the latest information on all experimental and theoretical aspects of crystal growth and characterization.

Topics to be emphasized are materials for energy, low pressure chemical vapor deposition, characterization of defects, materials in space, industrial crystallization, fluid flow dynamics, oxides and other crystals for high temperature applications, defects and device characterization, molecular engineering, organic and mineral crystallization, and eutectics, metals, and alloys. Presentations will be made in both lecture and poster sessions.

Persons interested in submitting papers in these and other areas should send abstracts by April 15 to Dr. Glenn Cullen, RCA Laboratories, Princeton, New Jersey 08540. The abstracts should be prepared on 8½ x 11 paper in camera-ready form, 1½ spaced. The abstracts should be two pages in length including tables, figures, and glossy photographs. Authors' names and addresses should be centered below the title. The title should be centered and underlined.

Persons interested in receiving future announcements of the conference should contact: Dr. Robert L. Parker, B164 Materials Building, 301/921-2961 or 2811.

CONFERENCE CALENDAR

*February 6–8

PROCUREMENT: MANDATED PROGRAMS UNER RCRA (PL 94-580) and EPCA (PL 94-163) sponsored by NBS and National Governor's Association; contact: Harvey Yakowitz, B160 Materials Building, 301/921-2343.

March 13–14

CONSTRUCTION DOCUMENTATION CONFERENCE; NBS, Gaithersburg, MD; sponsored by NBS, the Construction Specifications Institute, and the Guide Specifications Committee of the Federal Construction Council; contact: Roger Rensburger, B226 Technology Building, 301/921-3126.

March 22–24

28TH IEEE VEHICULAR TECHNOLOGY CONFERENCE; Denver, Colo; sponsored by NBS and the Institute of Electrical and Electronic Engineers; contact: John Shafer, NBS, Boulder, Colo., 303/499-1000, ext. 3185.

April 3–4

EMERGING PATTERNS IN AUTOMATIC IMAGERY PATTERN RECOGNITION; NBS Gaithersburg, MD; sponsored by NBS and Electronic Industries Association; contact: Russell Kirsch, A317 Administration Building, 301/921-2337.

April 10–13

TRACE ORGANIC ANALYSIS; A NEW FRONTIER IN ANALYTICAL CHEMISTRY, NBS, Gaithersburg, MD; sponsored by NBS; contact: Harry S. Hertz, A105 Chemistry Building, 301/291-2153.

April 17–20

AMERICAN NUCLEAR SOCIETY TOPICAL CONFERENCE ON COMPUTERS IN ACTIVATION ANALYSIS AND GAMMA RAY SPECTROSCOPY: Mayaguez, Puerto Rico; sponsored by NBS, American Chemical Society, American Nuclear Society, Energy Research and Development Administration, U. of Puerto Rico, Puerto Rico Nuclear Center; contact: B. S. Carpenter, B108 Reactor Building, 301/291-2167.

May 8–10

SYMPOSIUM ON REAL-TIME RADIOGRAPHIC IMAGING, NBS, Gaithersburg, MD; sponsored by NBS and the American Society for Testing and Materials; contact: Donald A. Garrett, A106 Reactor Building, 301/921-3634.

May 9–12

IONIZING RADIATION MEASUREMENT, NBS, Gaithersburg, MD; sponsored by NBS; contact: E. H. Eisenhower, C233 Radiation Physics Building, 301/921-2551.

May 18

TRENDS AND APPLICATIONS SYMPOSIUM: DISTRIBUTED PROCESSING; NBS, Gaitherburg, MD; sponsored by NBS, IEEE Computer Society; contact: Shirley Watkins, B212 Technology Building, 301/921-2061.

*May 22–24

TESTING SOLAR ENERGY MATERIALS AND SYSTEMS; NBS, Gaithersburg, MD; sponsored by Institute of Environmental Sciences, NBS, Department of Energy, and ASTM; contact: Joseph Richmond, B126 Technology Building, 301/921-2148.

June 5–7

3RD INTERNATIONAL SYMPOSIUM ON ULTRASONIC IMAGING AND TISSUE CHARACTERIZATION; NBS, Gaithersburg, MD; sponsored by NBS and National Institute of Health; contact: Melvin Linzer, A329 Materials Building, 301/921-2858.

June 12–13

MICROCOMPUTER BASED INSTRUMENTATION CONFERENCE, NBS, Gaithersburg, MD; sponsored by NBS, IEEE Society; IEEE Group on Instrumentation and Measurement; contact: Bradford Smith, A130 Technology Building, 301/921-2381.

June 15

TOOLS FOR IMPROVED COMPUTING IN THE 80's, NBS Gaithersburg, MD; sponsored by NBS, Washington, D.C. Chapter of the Association for Computing Machinery; contact: Trotter Hardy, A367 Technology Building, 301/921-3491.

June 19–21

GAS KINETICS CONFERENCE, NBS, Gaithersburg, MD; sponsored by NBS and the Committee on Chemical Kinetics, NBS, Committee on Chemical Kinetics of the National Academy of Sciences/National Research Council; contact: David Garvin, B154 Chemistry Building, 301/921-2771.

June 26–29

CONFERENCE ON PRECISION ELECTROMAGNETIC MEASUREMENTS, Ottawa, Ontario, Canada; sponsored by Institute of Electrical and Electronics Engineers, U.S. National Committee-International Union of Radio Science, and NBS; contact: Dee Belsher, NBS, Boulder, Colo., 303/499-1000, ext. 3981.

*July 13

WORKSHOP ON SUMMER ATTIC VENTILATION AND WHOLE HOUSE FANS, NBS, Gaithersburg, MD; sponsored by NBS; contact: Douglas M. Burch, B104 Building Research Building, 301/921-3513.

July 17–20

FOURTH ANNUAL CONFERENCE OF THE AMERICAN ASSOCIATION FOR CRYSTAL GROWTH, NBS, Gaithersburg, MD; sponsored by NBS and AACG; contact: Robert L. Parker, B164 Materials Building, 301/921-2961.

August 21–25

INTERNATIONAL ASSOCIATION FOR THE PROPERTIES OF STEAM, NBS, Gaithersburg, MD; sponsored by NBS and IAPS; contact: Howard White, A523 Administration Building, 301/921-2859.

*September 18–22

CHARACTERIZATION OF HIGH TEMPERATURE GASES, NBS, Gaithersburg, MD; sponsored by NBS; contact: John Hastie, A307 Materials Building, 301/921-2859.

* New Listings

PUBLICATIONS

GUIDELINE ON COMPUTER PERFORMANCE MANAGEMENT

Guideline on Computer Performance Management: An Introduction, Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS PUB) 49, 14 pages, $3.50.

Computer Performance Management (CPM)—a fundamental concept for Federal computer installation managers—is described in a new National Bureau of Standards publication titled *Guideline on Computer Performance Management: An Introduction.*

Recommending the establishment of a CPM program at all Federal computer facilities, the guideline provides general assistance to Federal computer installation managers in planning and organizing a CPM program—defined as "any structured effort to measure and evaluate the performance of installed computer systems in support of established management goals." The use of performance measures in four major areas of management responsibility is discussed. Special attention is given to the role of the computer center manager, and start-up requirements and other resources needed to effectuate a CPM program are outlined.

The guideline resulted from activities of the Federal Information Processing Standards (FIPS) Task Group 10 on Computer Performance Management, with cooperation from other sources both in and out of government.

USERS MANUAL FOR LNG MATERIALS AND FLUIDS

The National Bureau of Standards is offering for sale the first edition of a looseleaf LNG (liquefied natural gas) materials and fluids users manual. The publication is the first of its kind for up-to-date LNG data either generated experimentally or assessed and evaluated by NBS.

To order send check or money order payable to "National Bureau of Standards, Department of Commerce" to LNG Materials and Fluids Users Manual, Cryogenic Division, National Bureau of Standards, Boulder, CO 80302. For additional information contact: Douglas Mann at the same address or telephone 303/499-1000, ext. 3652. Cost of the first edition and binder is $35.

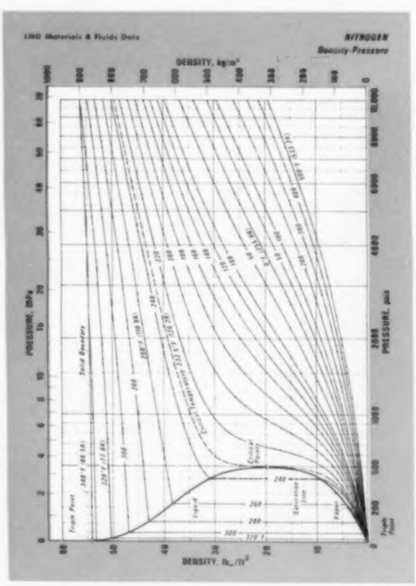
The manual is designed graphically to provide completed property data and related information for the effective generation, transport and use of LNG. The research was sponsored by the American Gas Association, the Department of Commerce's Maritime Administration, the NBS Office of Standard Reference Data, and the American Bureau of Shipping.

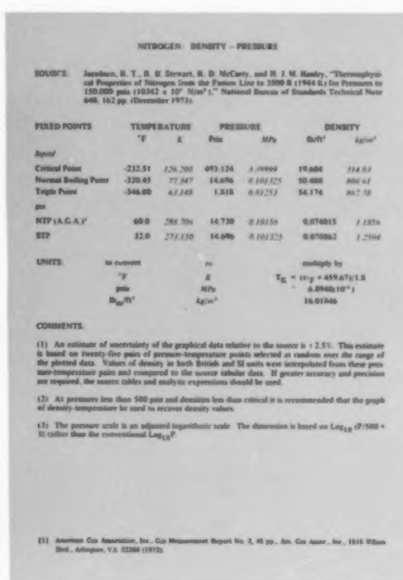
The initial edition contains 138 two-color (8 x 11-inch) charts. Property data included in the edition are pressure-density-temperature, thermodynamic, transport and electromagnetic properties of pure methane and nitrogen; fluid binary-mixtures of methane and nitrogen; and the elastic, thermal and mechanical properties of aluminum alloys (3005, 5083 and 6061), stainless steels (304, 304L, 310 and 316), nickel steels (2.25, 3.5, 5 and 9 percent alloyed), and invar. Six wall charts (22 x 34-inch) of the thermodynamic enthalpyentropy (H–S), pressure-enthalpy (P–H), and temperature-entropy (T–S) for pure methane and nitrogen are included also.

Six wall charts (22 x 34-inch) of the thermodynamic enthalpy-entropy (H–S), pressure-enthalpy (P–H) and temperature-entrophy (T–S) for pure methane and nitrogen are included also.

The expandable binder permits the addition of future supplements. Planned supplements involve pure fluids data on ethane, propane and iso and normal butane; fluid mixtures data of methane and ethane, propane and iso and normal butane; and, expanded materials data on thermal insulations, joining materials, structural composite materials and aggrates, polymeric materials and miscellaneous non-structural materials.

The six wall charts are available also for $1 each (Pressure-Enthalpy, Temperature-Entropy, Enthalpy-Entropy). Please specify the methane or nitrogen chart(s) desired. Purchasers of the first edition will be notified of the completion of additional supplements.





NITROGEN DENSITY – PRESSURE

SOURCE: Jacobsen, R. T., R. B. Stewart, R. D. McCarty, and H. J. M. Hanley, "Thermophysical Properties of Nitrogen from the Fusion Line to 3500 R (1944 K) for Pressures to 150,000 psia (10342 x 10⁵ N/m²)," National Bureau of Standards Technical Note 648, 162 pp. (December 1973).

FIXED POINTS	TEMPERATURE		PRESSURE		DENSITY	
	°F	K	Psia	MPa	lb/ft³	kg/m³
liquid						
Critical Point	-232.51	126.200	493.124	[illegible]	19.604	314.03
Normal Boiling Point	-320.45	77.347	14.696	0.101325	50.460	808.61
Triple Point	-346.00	63.148	1.818	0.01253	54.174	867.78
gas						
NTP (A.G.A.)[1]	60.0	288.706	14.730	0.10156	0.074015	1.1856
STP	32.0	273.150	14.696	0.101325	0.078062	1.2504

UNITS	to convert	to	multiply by
	°F	K	$T_K = (t_F + 459.67)/1.8$
	psia	MPa	6.8948(10⁻³)
	lb_m/ft^3	kg/m³	16.01846

COMMENTS

(1) An estimate of uncertainty of the graphical data relative to the source is ± 2.5%. This estimate is based on twenty-five pairs of pressure-temperature points selected at random over the range of the plotted data. Values of density in both British and SI units were interpolated from these pressure-temperature pairs and compared to the source tabular data. If greater accuracy and precision are required, the source tables and analytic expressions should be used.

(2) At pressures less than 500 psia and densities less than critical it is recommended that the graph of density-temperature be used to recover density values.

(3) The pressure scale is an adjusted logarithmic scale. The dimension is based on Log_{10} (P/500 + 1) rather than the conventional $Log_{10}P$.

[1] American Gas Association, Inc., Gas Measurement Report No. 3, 48 pp., Am. Gas Assoc., Inc., 1515 Wilson Blvd., Arlington, VA 22209 (1972).

Analytical Chemistry

Mielenz, K. D., Velapoldi, R. A., and Mavrodineanu, R., Eds., Standardization in Spectrophotometry and Luminescence Measurements. Proceedings of a Workshop Seminar held at the National Bureau of Standards, Gaithersburg, Md., Nov. 19-20, 1975, Nat. Bur. Stand. (U.S.), Spec. Publ. 147, 155 pages (May 1977) Stock No. 003-003-01791-4, $5.25.

Computer Science and Technology

Fife, D. W., Computer Science and Technology: Computer Software Management: A Primer for Project Management and Quality Control, Nat. Bur. Stand. (U.S.), Spec. Publ. 500-11, 58 pages (July 1977) Stock No. 003-003-01795-7, $2.

Hardy, I. T., Hong, B. L., and Fife, D. W., Computer Science and Technology: Software Tools: A Building Block Approach, Nat. Bur. Stand. (U.S.), Spec. Publ. 500-14, 66 pages (Aug. 1977) Stock No. 003-003-01823-6, $2.10.

Health and Safety

Brungraber, R. J., A New Portable Tester for the Evaluation of the Slip-Resistance of Walkway Surfaces, Nat. Bur. Stand. (U.S.), Tech. Note 953, 51 pages (July 1977) Stock No. 003-003-01796-5, $2

Shand, W. A., and Teado, M. J., Police Communications Equipment Survey of 1976, Nat. Bur. Stand. (U.S.), Spec. Publ. 480-13, 53 pages (Aug. 1977) Stock No. 003-003-01818-0, 75 cents.

Electronic Technology

Blackburn, D. L., Semiconductor Measurement Technology: Safe Operating Area Limits for Power Transistors, Nat. Bur. Stand. (U.S.), Spec. Publ. 400-44, 20 pages (Sept. 1977) Stock No. 003-003-01833-3, $1.

Energy Conservation and Production

Becker, D. A., Ed., Measurements and Standards for Recycled Oil. Proceedings of a Workshop held at the National Bureau of Standards, Gaithersburg, Md., Nov. 22 and 23, 1976, Nat. Bur. Stand. (U.S.), Spec. Publ. 488, 140 pages (Aug. 1977) Stock No. 003-003-01831-7, $3.

Engineering, Product and Information Standards

American National Standard N537; Radiological Safety Standard for the Design of Radiographic and Fluoroscopic Industrial X-ray Equipment, Nat. Bur. Stand. (U.S.), Handb. 123, 15 pages (Aug. 1977) Stock No. 003-003-01820-1, 90 cents.

Clark, G., Character Structure and Character Parity Sense for Parallel-by-Bit Data Communication in the Code for Information Interchange, Nat. Bur. Stand. (U.S.), Fed. Infor. Process. Stand. Publ. (FIPS PUB) 18-1, 4 pages (1977).

Clark, G., Synchronous Signaling Rates Between Data Terminal and Data Communication Equipment, Nat. Bur. Stand. (U.S.), Fed. Infor. Process. Stand. Publ. (FIPS PUB) 22-1, 4 pages (1977).

Metrology: Physical Measurements

Hellwig, H., Frequency Standards and Clocks: A Tutorial Introduction, Nat. Bur. Stand. (U.S.), Tech. Note 616 (2d Rev.), 70 pages (June 1977) Stock No. 003-003-01798-1, $1.30.

Nuclear Physics and Radiation Technology

Dressler, E. T., Threshold Photo and Electroproduction of Pions From Nuclei, Nat. Bur. Stand. (U.S.), Tech. Note 957, 38 pages (Sept. 1977) Stock No. 003-003-01834-0, $1.50.

Maximon, L. C., Electromagnetic Interactions From 5 to 400 MeV and Nuclear Research—A Position Paper as of March 1977, Nat. Bur. Stand. (U.S.), Tech. Note 955, 51 pages (Aug. 1977) Stock No. 003-003-01816-3, $2.

Processing and Performance of Materials

Shives, T. R., and Williard, W. A., Eds., MFPG—Engineering Design. Proceedings of the 25th Meeting of the Mechanical Failures Prevention Group, held at the National Bureau of Standards, Gaithersburg, Md., Nov. 3-5, 1976, Nat. Bur. Stand. (U.S.), Spec. Publ. 487, 367 pages (Aug. 1977) Stock No. 003-003-01829-5, $5.25.

Properties of Materials

Roth, R. S., Cook, L. P., Negas, T., Cleek, G. W., and Wachtman, J. B., Jr., User Evaluation of "Phase Diagrams for Ceramists" and Implication for Related Data and Research Programs, Nat. Bur. Stand. (U.S.), Spec. Publ. 486, 70 pages (Aug. 1977) Stock No. 003-003-01827-9, $2.10.

Publications listed here may be purchased at the listed price from the U.S. Government Printing Office, Washington, D.C. 20402 (foreign: add 25%). Microfiche copies are available from the National Technical Information Service, Springfield, VA 22161. For more complete periodic listings of all scientific papers and articles produced by NBS staff, write: Editor, Publications Newsletter, Administration Building, National Bureau of Standards, Washington, D.C. 20234.

DIMENSIONS/NBS
Change of Address Form

NAME—FIRST, LAST

COMPANY NAME OR ADDITIONAL ADDRESS LINE

STREET ADDRESS

CITY | STATE | ZIP CODE

PLEASE PRINT

MAIL THIS FORM TO:

NEW ADDRESS
Superintendent of Documents
Government Printing Office SSOM
Washington, D.C. 20402

Attach last subscription label here

NEWS BRIEFS

AMBLER BECOMES NBS DIRECTOR. Dr. Ernest Ambler was confirmed by the U.S. Senate on February 1 as the eighth director of the National Bureau of Standards. As director of NBS, he leads the nation's central reference laboratory for measurements. Ambler holds B.S., M.A., and Ph.D. degrees in physics from Oxford University. He joined NBS in 1953.

PROPOSALS SOLICITED FOR RESEARCH GRANTS. NBS is soliciting proposals for the award of two research grants in the field of precision measurements and the determination of fundamental physical constants. The grants, worth $25 000 per year, are awarded annually to scientists in academic instititutions and may be renewed for an additional two years. Prospective candidates for the 1979 awards must submit summaries of their proposed projects and biographical information to NBS by April 15. The grants will run from October 1, 1978 through September 1979. Contact: Dr. Barry N. Taylor, NBS, B258 Metrology Building, Wash., D.C. 20234; 301/921-2701.

FIELD TESTING SMOKE DETECTORS. NBS has developed a portable prototype instrument for field testing installed smoke detectors. It can be used to determine their performance and sensitivity under different environmental conditions. The new instrument, a smoke aerosol-generator, was designed by the NBS Center for Fire Research. For more information contact the Center for Fire Research, NBS, Wash., D.C. 20234; 301/921-3143.

POSSIBLE LINK BETWEEN AIR QUALITY AND LEAD POISONING. Conventional theories about lead poisoning in children hold that the major source of the absorbed lead is paint in old and deteriorating buildings. A recent study by NBS suggests that air quality may be an equal if not more important factor. In a project sponsored by the Department of Housing and Urban Development, NBS mathematicians analyzed some 300 000 lead poisoning records collected in New York City between 1970 and 1976. They found that the varying amounts of lead in children's blood followed a seasonal pattern related to the changing level of atmospheric lead. The Environmental Protection Agency is presently considering a new regulation governing the amount of lead in the air.

NBS BUDGET FOR FY 1979. A total of $94 364 000 is included for NBS in the Budget of the United States for Fiscal Year 1979. This is nearly $23 million above the FY 1978 operating level and will represent a 32 percent increase in funding, if appropriated. The additional funds will be used to strengthen research on physical measurements, basic science, and materials and to develop computer standards. The total budget for NBS could total $155 million in FY 1979, a figure which includes the requested direct congressional appropriations, reimbursable work which NBS performs for other federal agencies and the public, and sales of Bureau goods and services.

NEXT MONTH IN

DIMENSIONS NBS

Operating a mobile radio in an area where there is blasting can be dangerous. A signal generated from such a radio can trigger the blasting caps on the dynamite. This is only one of the problems caused by electromagnetic interference. Get a perspective on EMI in the next issue of DIMENSIONS/NBS.

U.S. DEPARTMENT OF COMMERCE
Juanita M. Kreps, Secretary
Sidney Harman, Under Secretary

Jordan J. Baruch, Assistant Secretary for Science and Technology

NATIONAL BUREAU OF STANDARDS
Ernest Ambler, Director

Prepared by the NBS Office of Information Activities
Washington, D.C. 20234
Richard S. Franzen, Chief

Madeleine Jacobs, Chief, Editorial Section

Juli Kelley, Editor

Justine A. Williams, Editorial Assistant

Charles Messina, Jr., Visual Editor
(Commerce Department)

PHOTO CREDITS
Mark Helfer

The National Bureau of Standards was established by Congress in 1901 to advance the Nation's science and technology and to promote their effective application for public benefit. Manufacturing, commerce, science, government, and education are principal beneficiaries of NBS work in the fields of scientific research, test method development, and standards writing. DIMENSIONS/NBS describes in technical and general terms results of NBS activity in areas of national concern such as energy conservation, fire safety, computer applications, environmental protection, materials utilization, and consumer product safety and performance. The functions of NBS are divided among four major institutes: Institute for Basic Standards, Institute for Materials Research, Institute for Applied Technology, and Institute for Computer Sciences and Technology.

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Annual subscription: Domestic, $12.50, foreign, $15.65, single copy, $1.05. The Secretary of Commerce has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director of the Office of Management and Budget through June 30, 1981.

AN EQUAL OPPORTUNITY EMPLOYER

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards
Washington, D.C. 20234

OFFICIAL BUSINESS
Penalty for Private Use, $300
RETURN POSTAGE GUARANTEED

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF COMMERCE
COM-215
CONTROLLED CIRCULATION RATE

U.S.MAIL

DNBS SERIA300SEISSDUE012R 1
SERIALS PROCESSING
UNIVERSITY MICROFILMS INTL
300 N ZEEB RD
ANN ARBOR MI 48106